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Wire, Heal Thyself

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07.31.2008 | Faculty, Science, Research Wire, heal thyself: The researcher who identified a plausible cause of the explosion that downed TWA flight 800 in 1996 has developed a self-healing wire designed to prevent that kind of explosion from recurring.

And because he's a fan of baseball, University of Dayton Research Institute chemist Bob Kauffman made an accidental, secondary discovery that could prove equally lifesaving: damaged aircraft wires exposed to moisture emit radio frequencies just before they short out – a phenomenon that could allow them to be readily located with a simple "listening" device before they cause any damage.

Kauffman and his colleagues at UDRI were part of a multi-organization team hired by the FAA in 1999 to determine the cause of the center-wing fuel tank explosion that brought down TWA 800. The Boeing 747 crashed into the Atlantic Ocean shortly after takeoff from New York City's Kennedy Airport July 17, 1996, killing all 230 passengers and crew members. The researchers determined that frayed fuel-sensor wiring likely played a significant role in the explosion.

During his research, Kauffman also showed that frayed wires exposed to moisture in a fuel tank cause conductive fuel residues to form. "If those residues are exposed to DC electricity from faulty wiring, they become red hot and can ignite the surrounding fuel," he said.

"Aging aircraft wire is a major challenge to the aerospace industry. Over time, bending, chafing and brittleness cause insulation to wear or break away, which can lead to arcing of the bare copper conductor. The results can range from maintenance headaches to a catastrophic event."

One frayed wire might be fairly innocuous, Kauffman said, but commercial aircraft contain "miles and miles of wiring, all bundled together. And when two frayed wires in close proximity start sparking, they can form combustible residues that eventually ignite and take out the entire bundle – like someone lighting a fuse."

But locating faulty wiring is a daunting task at best, because much of it is not easily accessible. "You don't want to be taking apart bundles of wire just to look for a couple of hairline cracks," Kauffman said. "You can do a lot more damage to good wires trying to find and fix a bad one."

Kauffman's solution is a PATCH – Power-Activated Technology for Coating and Healing – for wire insulation. The inexpensive and nontoxic formula draws on water and electricity to chemically transform itself into a permanent coating.

The PATCH system comes in two forms, both based on polyvinyl alcohol. One is a water-based liquid, similar to a contact lens solution which can be misted into hard-to-reach compartments. The other is a solid, water-soluble material, much like coatings used on vitamins and pain relief tablets, to be embedded as an inner layer of coating during wiring manufacture.

"The liquid can be sprayed directly onto wire bundles," Kauffman said. "If it comes into contact with any live wire with damaged insulation, the electrical current will transform the spray into an insoluble polymer coating. Any solution not coming into contact with exposed wire will wash away, preventing weight-build up from repair activity."

The solid PATCH is built into the wiring between the copper wire and its insulation. Already in contact with electrical current, the chemical coating needs only water to transform into a permanent repair – which takes place when the insulation is breached.

"When a plane lands, it's full of water," Kauffman said, explaining that condensation occurs when an aircraft descends from freezing, high-altitude temperatures to warmer low-altitude temperatures. "So if there is a break in the outer insulation, moisture inside the aircraft activates the chemical process that transforms the soluble inner coating into a permanent seal."

Kauffman is working to commercialize both products, believing the need for self-healing wire is as great in industry as in aerospace. "One of the biggest problems out in the field is intermittent electrical trouble," Kauffman said. "The self-healing coating is so inexpensive to produce, it could easily be used in electrical applications ranging from home repair to industrial power boxes."

Kauffman has been awarded an additional $200,000 in FAA funding to further develop and test the PATCH technologies, which are patent pending, as well as for research into sensors that would monitor the stability of wire bundles and connectors, and for "smart clamps" that will report whether they are damaged or not functioning properly.

Some of the funds will also be used to develop a new technology designed to find faulty wires before they cause harm with a device as simple as, and similar to, an AM radio – technology born by accident in Kauffman's affinity to baseball.

"I was conducting experiments in the lab to recreate the scenario that most likely caused the TWA fuel tank explosion, and a baseball game was playing on a radio in the background. Every time I put a drop of water on live copper wires, the game went away," he said. "It just went to static. I realized that wet copper wires give off a radio frequency just before shorting out."

Kauffman said technicians could use hand-held listening devices to locate faulty wires, or the devices could be planted on runways to listen for wire "chatter." The same technology could also be used in industrial applications – such as automobile repair, a market Kauffman is currently pursuing.

"With the ever-increasing amount of wiring being used in cars and trucks comes an increased number of intermittent electrical problems from frayed wiring," he said. "If those wires can't be easily located visually, they could be detected using a spray of water to cause them to produce radio frequencies – then repaired with self-healing spray. If the technology proves successful in professional repair shops, it could find its way into auto parts stores as well."

The University of Dayton Research Institute has a significant history in researching and addressing aging aircraft issues, much of it for the Department of Defense. In 2003, the DoD funded UDRI, Texas A&M Engineering and Georgia Tech Research Institute to establish and operate the Academic Center for Aging Aircraft. The ACAA provides research and development support for the Joint Council on Aging Aircraft in the areas of structural integrity, wiring, coatings, corrosion, material repair and propulsion life.

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